with the silvery sheen much less noticeable; and in the thoracic dorsum being less brassy pollinose. It is an intermediate form between *Thomsoni* and *iterans*; from *iterans* it differs in the front tarsi of female being widened, abdomen more deeply tinged with red, and dorsum of thorax less brassy pollinose. Palpi are slender, filiform, as in both *iterans* and *Thomsoni*.

Three of the above specimens have three bristles on sides of face near orbits, instead of only two.

Also one female, Rio Ruidoso, 4 miles west of Dowling's Mill, 6600 feet, July 10, on flowers of sumac, *Rhus glabra*, L. (*Wooton*).

23. *Echinomyia*, sp.

Two specimens (male and female) of a blackish species, with a stigma-like spot on wings. Taken by Prof. Wooton on White Mountain, 9000 feet, July 3, on flowers of *Helenium Hoopesii*, Gray.

XIV.—*The Physiological Importance of the Air-Spaces in Flying Animals.* By R. von Lendenfeld *.

It is well known that in the bodies of the majority of insects and birds large spaces filled with air are met with which appear morphologically as local expansions, relatively as appendages of the respiratory organs. They are developed in very different ways in the different species, and are not present in all insects. In general it may be said that in animals capable of strong and sustained flight they are highly developed and spacious, that in bad fliers they attain a lower degree of development or (as in some insects) do not occur at all, and that in all non-flying insects they are entirely wanting. It is thus rendered probable that they are in some way directly or indirectly connected with the flying motion, and are to be regarded physiologically as organs subservient to flight. Further, from the very considerable size of these organs, especially in Hymenoptera and many birds, a conclusion may be drawn as to the great importance which they must possess.

With reference to these air-spaces three suppositions are possible:—(1) they are exclusively accessory respiratory

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organs or an auxiliary breathing-apparatus; (2) they are exclusively mechanical locomotor organs (structures for the maintenance of equilibrium and the regulation of specific gravity); (3) they perform both of these functions.

We might well suppose that good and powerful fliers, just as they have a relatively heavier heart than other birds (Parrot), also need especially efficient respiratory organs, and that accordingly their air-sacs are breathing-organs. The air-sacs themselves, however, cannot be respiratory organs, on the one hand since they exhibit no arrangements whatever for increasing their surface (folds, cells, or similar developments), and on the other hand because (in birds) the membrane which bounds them is in general poorly supplied with blood-vessels (Drosier and other authors). It is only on the inner surface of pneumatic bones that we find capillaries in greater abundance, and here, moreover, the excretion of carbonic acid has been demonstrated experimentally (Baer). Nevertheless the respiration in this case cannot be anything considerable, since in these rigid cæca-like chambers the air must be in a state of almost complete stagnation. But although oxidation of the blood takes place only to an altogether inconsiderable extent in the walls of the air-sacs, these structures might still as a motor-apparatus, as bellows, play an important part in respiration; they might have to provide for the active ventilation of the parts which actually oxidize the blood. It was formerly supposed that the intra- and extra-thoracic air-sacs of birds contracted alternately, and that by this means the air was forced to and fro through the lungs (Sappey). The results of later investigations, however, obtained by the aid of the graphic method, and as to the correctness of which no doubt whatever can exist, have shown that the air-pressure in all air-sacs rises and falls simultaneously. There is consequently no current of air from air-sac to air-sac, but only a current passing to and fro between the mouth and the air-sacs. Now although the air-sacs communicate directly with the bronchi through wide open tubes, nevertheless a great part of the air that streams to and fro between the mouth and the air-sacs, especially in expiration, is said to pass through the fine canals of the lungs and to renew continually the air in the pulmonary alveoli (Baer). To this, however, it must be objected that the anatomical conditions do not support the justice of this assumption. If this were the sole or the most essential function of the air-sacs, we should, at any rate, expect to meet with arrangements which would cause the whole of the air in the air-sacs, or, at least, the greater portion of it, to pass through the actual respiratory part of the breathing-apparatus. There are no such arrangements, however. In insects, by means of wide sections of tracheal tubes, the great air-vesicles are in direct, immediate, and free communication with the stigmata, so that the air which enters them from without and that which is given off from them to the exterior cannot pass through the respiratory terminal branches of the ramifying tracheal trunk. In birds the cephalic air-sacs, as well as some of the subcutaneous ones in certain species, are connected with the nasal cavity; consequently the currents of air passing to and fro between these sacs and the exterior cannot enter into the lungs at all. The air-sacs of the body and limbs communicate with the bronchi, with which they are openly connected by means of wide canals. It is true that from the walls of these spacious tubes, which traverse the lungs, there arise narrow ducts which lead into the actual lung-parenchyma; but in spite of this the greater part of the air, which passes to and fro between the exterior and these sacs, will take its course through those wide tubes, and it is only quite insignificant driblets from the air-stream that will pass through the parenchyma of the lungs.

The cephalic air-sacs and the subcutaneous air-sacs belonging thereto in birds, as well as the majority of the air-sacs in insects, consequently do not contribute at all, while the remaining air-sacs contribute only in a very slight degree, by no means in proportion to their size, to the ventilation of the parts of the body which absorb oxygen and excrete carbonic acid. As an accessory respiratory apparatus they can therefore at best function only incidentally: their chief function must be a different one.

We thus arrive at the second and third of the alternatives stated above: we have to ask in what manner the air-sacs can mechanically support the faculty of flight. In any case they reduce the specific gravity of the body very considerably, and I presume that this might increase the power of flight, and especially facilitate materially the maintenance of equilibrium in the air, although the enlargement of the body connected therewith would considerably increase the resistance of the air, particularly in rapid flight, and so under certain circumstances would also bring disadvantages in its train.

Since the air contained in the pneumatic spaces in warm-blooded birds has a higher temperature than the outer air, the air-sacs in them certainly have a direct lifting effect—they operate as balloons—but this is so inconsiderable that practically it cannot come into account at all.

Apart from those air-cavities that (in birds) extend in the bones, and the object of which—the reduction of the weight of the bones without impairing their strength—is distinctly evident, all air-chambers are readily contractile and dilatable. The spiral thread of chitin that stiffens the tracheæ in insects is absent from the walls of their larger air-chambers, and in birds the walls of the air-sacs of the body are very delicate and soft membranes.

It appears certain that flying animals have the power, by means of voluntary contraction of the body-muscles, to alter very rapidly the degree of fullness of these air-chambers (of course with the exception of those that are situated in the bones), and that thus they are enabled to displace their own centre of gravity, and to change the specific gravity as well as the size of their parts. But we now have to ask how changes of this kind can be of so great an advantage to flight as to explain the extraordinarily high degree of the development of these cavities in good fliers.

In insects the air-chambers have manifold connexions one with another by means of various tracheal tubes; in birds an intercommunication between them does not appear to exist.

The most spacious air-bladders, in birds as well as in insects, are met with for the most part in the abdomen. In certain cases (in dragonflies and the condor) the air-chambers of the head are also very large.

In the case of insects it might be supposed that by means of a sudden discharge of considerable quantities of air from the stigmata of one side, or from only one particular stigma, a rebound might be produced which would entail a definite and advantageous lateral or turning movement of the body. A process such as this would be materially facilitated by the connexion of the air-chambers of the two symmetrical halves of the body. In the case of birds, however, an explanation of this kind is naturally impossible.

Since those birds that for the most part soar—that is, without strokes of their wings move, maintain themselves aloft, and even ascend—possess quite peculiarly well-developed air-chambers (I would remind the reader only of the pelican and certain large Raptores), it is natural to suppose that it is precisely in soaring that these structures come most into play. Since soaring requires only slight muscular labour, increasing the intensity of breathing but little, their high degree of development in birds which soar is an argument against the assumption that the air-sacs are nothing more than accessory respiratory organs.

In order to be able to give a decision as to their mechanical function in the act of soaring we must first seek to determine how soaring birds perform this remarkable movement. It is certain that soaring and circling depend on overcoming the force of gravity by the aid and employment of the force inherent in the wind. Now the way in which this is turned to account appears to a certain extent doubtful. In the event of the speed of the wind increasing sufficiently quickly with increasing altitude the bird is able, by using the increment of the force of the wind, to mount in circles without a stroke of its wings (Lord Rayleigh). The wind is also said to be very irregular, to blow at any given point with quickly changing strength and, to a slight extent, with quickly changing direction. By utilizing the differences in the force and direction of the wind the bird can likewise keep itself poised and also ascend without flapping its wings (Langley). Lastly, the bird is able by circling, precisely like a rapidly rotating top, to acquire a certain inherent stability, which, operating like the string of a kite, renders it capable, when the current of air is continuous and perfectly equable in force, of soaring and ascending like a kite (Lendenfeld).

Be this as it may, soaring at any rate depends upon an admirable utilization of the force of the wind, which is only attained by the bird always setting its expanse of sail, the whole underside of its body (Müllenhoff), precisely in the proper angle with the horizontal plane and with the direction of the wind. This process must be very difficult—indeed, it is hardly possible to imagine how a free-soaring bird, which presents a large surface of sail to the wind, in the midst of violent currents of air and in a constantly changing position, without any fixed point of attachment, can maintain its equilibrium, and can regulate efficiently, with ease and precision, the inclination of the surface of sail which it forms.

Since the bird soars free, the position of the surface of sail can really be attained only by changes in the position of the centre of gravity with reference to the expanse of sail, as well as by alterations of the parts that feel the resistance of the air. But changes of this kind in the position of the centre of gravity and alterations of the resisting surfaces can be brought about by alterations in the degree of fullness of the various air-sacs, since by their inflation parts of the body are enlarged and forced away from the centre. It is true that these changes are small, but even small changes of this sort will be enough to produce a considerable and sufficient result.

Although this action of the air-sacs is most distinctly marked in soaring, it will nevertheless also come into operation in ordinary flight with strokes of the wings, in which, indeed, the kite-like action of the spread of sail always comes jointly into play to a greater or less degree.

Granted, therefore, that the air-sacs to a certain extent assist respiratory activity, that is, in the case of birds, their main object will still be a mechanical one—the reduction of the specific gravity of the whole animal and the regulation of the specific gravity and the size of its parts, as well as of the position of the centre of gravity.

XV.—*Description of a new Snake from Sierra Leone.* By G. A. Boulenger, F.R.S.

Aparallactus niger.

Diameter of eye greater than its distance from the oral margin. Rostral much broader than deep, the portion visible from above one third as long as its distance from the frontal; internasals slightly broader than long, widely separated from the præocular; a single præfrontal, forming sutures with the nasal and præocular; frontal nearly once and a half as long as broad, as long as its distance from the end of the snout, much shorter than the parietals; nasal semidivided, in contact with the præocular; two postoculars; a single temporal; seven upper labials, third and fourth entering the eye, fifth and sixth in contact with the parietal; first lower labial in contact with its fellow behind the symphysial; anterior chin-shields longer than the posterior, in contact with four lower labials. Scales in 15 rows. Ventrals 164; anal entire; subcaudals 60. Uniform black above; ventrals white, edged with black; subcaudals black in the middle and on the posterior and outer borders.

Total length 335 millim.; tail 80.

A single male specimen in a small collection made by Mr. W. G. Clements in Sierra Leone.

The same collection contained a specimen (head and neck only) of *Naia Guentheri*, Blgr., the habitat of which was still unknown.